

## REMARKS

The applicant appreciates the Examiner's thorough examination of the application and requests reexamination and reconsideration of the application in view of the preceding amendments and the following remarks. The applicant further appreciates that Examiner Martir granted and engaged in (with Examiner Patel) a telephone conference on July 16, 2003 with the undersigned. The applicant will address Examiner Martir's rejections as set forth in the June 10, 2003 Office Action, as well as again attempt to address the Examiners' concerns expressed during the telephone conference, including questions regarding the *Bruner* reference and Examiner Martir's closing comments concerning the applicant's claims and their recitation of structure.

### *Donelan et al.* and *Sheen et al.* Each Teach Away From The Applicant's Claimed Invention

In the Office Action, the Examiner rejects claims 1, 3, 4, 8-10, and 13 under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 4,598,593 to *Sheen et al.* in view of U.S. Patent No. 4,003,256 to *Donelan et al.* As discussed below, both *Donelan et al.* and *Sheen et al.* teach away from the applicant's claimed invention, they do not inherently teach the applicant's claimed invention, and one skilled in the art at the time of the applicant's invention would not have been motivated to combine the primary reference *Sheen et al.* with the secondary reference *Donelan et al.*

The applicant's invention of claim 1 recites an ultrasonic measurement system for determining flow of gas or low density fluid in a conduit, the system comprising a first clamp-on transmitter receiver pair configured to define a first ultrasonic signal path across fluid

flowing in the conduit, a second clamp-on transmitter receiver pair configured to define a second ultrasonic signal path across fluid flowing in the conduit, the second clamp-on transmitter receiver pair being mounted so that the second ultrasonic signal path is anti-parallel to the first path and spaced a fixed distance therefrom, and a processor operative to correlate a tag-modulated output signal of the first pair with a tag-modulated signal of the second pair to determine a time interval representative of flow.

The applicant claims anti-parallel tag flow measurement by transmitting ultrasonic energy across the fluid motion. The applicant claims a clamp-on transducer system. The applicant claims two ultrasonic signal paths. The applicant claims that the output signals from the first and second transmitter receiver pairs are tag-modulated output signals, and a processor to correlate those tag-modulated output signals. The applicant's claimed invention resolves a long-felt need for reduction of crosstalk extending from one transmitter to the receiver of the other pair in tag flow measurement systems by using anti-parallel signal propagation paths. This problem is especially important when dealing with the claimed low density fluids (such as steam, natural gas or air). This problem becomes apparent immediately to any capable experimenter who tries to measure, for example, the flow of ordinary air in a steel pipe. Elimination of crosstalk carried by the pipe is a major hurdle when applying clamp-on measurement techniques to the measurement of low density gas flow.

In contrast to the applicant's claimed invention, *Sheen et al.* teaches away from the applicant's claimed invention because *Sheen et al.* teaches flow measurement using parallel, not anti-parallel paths. The improved result using anti-parallel paths as opposed to parallel paths with tag flow measurement is striking, as shown by applicant's Figs. 6A and 6B. *Sheen et al.* teaches away from the applicant's claimed invention which achieves reduction of crosstalk

using anti-parallel ultrasonic paths because *Sheen et al.* teaches reduction of crosstalk by means of an “acoustic decoupler” 12 between pipe sections. See, e.g., *Sheen et al.* at column 2, lines 65-68 and the Abstract. *Sheen et al.* admits that “it is extremely difficult to get a usable signal from cross-correlation” and states that “[t]his problem is overcome by inserting an acoustic decoupler between the sensors generating the acoustic signal applied to the pipe wall”. *Sheen et al.* column 2, lines 14-22. The system of *Sheen et al.* could not be used with, for example, conduits for combustible gas flow, for at least safety reasons. Also, *Sheen et al.* cross-correlates the noise signal from particle impingement on the pipe wall, see *Sheen et al.* column 2, lines 9-16 and column 3, lines 8-11.

The teachings of the secondary reference *Donelan et al.* are also in contrast to the applicant’s claimed invention. *Donelan et al.* teaches away from the applicant’s claimed clamp-on transducers because *Donelan et al.* teaches monitoring the effect of fluid motion “by positioning the transducers 13a-14a and 13b-14b in the fluid”. See, e.g., column 2, lines 64-68. Also, because *Donelan et al.* teaches transducers in the fluid, *Donelan et al.* does not teach reduction of crosstalk in conduits, and one skilled in the art would not look to *Donelan et al.* for a solution to crosstalk noise. Additionally, *Donelan et al.*’s transducers are in the fluid, and the ultrasonic energy as taught by *Donelan et al.* is transmitted within the fluid motion in the direction of, and opposite the direction of, fluid flow, not across the fluid motion, i.e. from a transmitting transducer to a receiving transducer each clamped on to the outside of the conduit. Moreover, in contrast to the applicant’s claimed tag-modulated signals output by the transducer receiver pairs that are correlated by the claimed processor, the analysis and control circuits 17 and 19 in Figs. 1 and 2 of *Donelan et al.* “basically determine the difference or beat frequency between the resonant frequencies of the acoustic energy propagation upstream in the direction of

fluid motion and downstream in the direction opposite to fluid motion”. *Donelan et al.* column 4, lines 19-24.

Also, *Donelan et al.* teaches that the two ultrasonic energy paths are necessarily as close as practical. See, e.g., Fig. 1, where the two paths are much closer than the distance between the transducers. In fact, *Donelan et al.* teaches that the device may have a single periodically reversing acoustic path. See, e.g., column 3, lines 11-14. This arrangement is consistent with contrapropagation theory as it is known in the art, where in order to achieve higher accuracy, interrogation occurs in opposite directions over the same path or in as close to the same path as physics allows. This eliminates sound speed as a variable so flow velocity can be determined. Also, *Donelan et al.* teaches that “it is useful to operate the oscillators at a known harmonic of the fundamental for the path”. See column 3, lines 28-30. In contrast, it is known that two paths are necessary for tag flow measurement, and if tag paths are *too* close it is increasingly difficult to determine the time for the modulation to pass from one path to the next with sufficient accuracy.

These latter points make clear the stark contrast between *Donelan et al.* and the applicant’s claimed invention and these points may touch upon the essence of many of the Examiner’s rejections. That is, words or terms in the applicant’s claims cannot simply be picked and combined from a variety of diverse references when the fundamental theories behind the systems and methods of the cited references are incompatible. In this latter example, although *Donelan et al.* teaches two paths in one embodiment, the fact that *Donelan et al.* teaches an alternative of one path in a second embodiment demonstrates that *Donelan et al.* teaches away from the applicant’s claimed invention as a whole. The applicant’s claimed invention using anti-parallel tag flow measurement detects a similar pattern of modulation on

two paths at different times, and derives the fluid velocity from the distance between the paths divided by the elapsed time between occurrence of correlated modulated patterns. See, e.g., the application at page 1, lines 19-21.

Finally, *Donelan et al.* utilizes so-called “anti-parallel” not for reduction of crosstalk in the conduit (indeed, *Donelan et al.* teaches that the transducers are in the fluid), but to eliminate the speed of sound factor from the equation for flow. While *Donelan et al.*’s “anti-parallel” paths may be parallel and oppositely directed, one skilled in the art would recognize that *Donelan et al.* teaches contrapropagation flow measurement, not anti-parallel flow measurement as these terms are known in the art. *Donelan et al.* “transmits continuous wave ultrasonic energy in the direction of fluid motion and against the fluid motion”, see, e.g., column 1, lines 8-9. This is the essence of contrapropagation measurement as it is known in the art. See also column 4, lines 19-24. *Donelan et al.* does not teach tag-modulated flow measurement, clamp-on transducers, or that its transducer receiver pairs output tag-modulated signals, in contrast to the applicant’s claimed invention.

#### The Elements of Applicant’s Claims Are Not Inherent In the Cited References

The elements claimed by the applicant are not functional, but structural. First and second clamp-on transmitter receiver pairs are configured to define first and second ultrasonic signal paths, the second clamp-on transmitter receiver pair being mounted so that the second path is anti-parallel to the first path, and the first and second transmitter receiver pairs output tag-modulated output signals. Even if the Examiner is of the opinion that portions of the claims are functional, the Examiner is not allowed to delete functional elements of a claim before determining obviousness. A patent applicant is free to recite features of an apparatus either

structurally or functionally. In re Schreiber, 128 F.3d 1473, 44 USPQ 2d 1429, 1432. Quoting In re Swinehart, 439 F.2d 210, 212, 169 USPQ 226, 228 (CCPA 1971), the Schreiber court noted that if the Patent Office has a reason to believe that a functional limitation asserted to be critical for establishing novelty in the claimed subject matter may be an inherent characteristic of the prior art, it possesses the authority to prove that the subject matter shown in the prior art does not possess the characteristic relied on. The Schreiber court then stated:

The Examiner and the Board both addressed the question whether the functional limitations of Schreiber's claim gave it patentable weight and concluded they did not, because those limitations were found to be inherent in the Harz prior art reference...

... At that point, the burden shifted to Schreiber to show that the prior art structure did not inherently possess the functionally defined limitations of his claimed apparatus.

Here, the Examiner has not addressed the question whether or not the applicant's "functional limitations" were found to be inherent in the cited references. Indeed, even assuming arguendo that the applicant's recited elements are functional, the cited references do not teach the elements of the applicant's claimed invention, explicitly or inherently. Use of anti-parallel signal paths with tag-modulated flow measurement to reduce crosstalk would not be inherent in *Sheen et al.* because *Sheen et al.* teaches the diametrically opposite techniques of parallel ultrasonic paths, with an acoustic decoupler to reduce crosstalk. Use of anti-parallel signal paths with tag-modulated flow measurement to reduce crosstalk would not be inherent in *Donelan et al.* because *Donelan et al.* teaches transducers in the fluid, not clamp-on; does not teach concerning conduit noise or its elimination; does teach contrapropagation, not true anti-parallel, as one skilled in the art would recognize; and does teach an alternative embodiment of one path, which one skilled in the art would recognize as being founded on a fundamentally

different principle than tag flow measurement, the latter requiring more than one path, not too closely spaced, and thus *per se* not inherent in *Donelan et al.*

One Skilled In The Art Would Not Be Motivated To Combine *Sheen* and *Donelan*

Further, one skilled in the art would not be motivated to combine *Sheen et al.* and *Donelan et al.* Inter alia, *Sheen et al.* teaches transducers outside of a conduit (and consequently outside of the fluid flow), while *Donelan et al.* teaches placing transducers in the fluid. *Sheen et al.* teaches an acoustic decoupler to reduce crosstalk, while *Donelan et al.* does not mention conduits, or crosstalk. *Sheen et al.* teaches parallel ultrasonic paths; *Donelan et al.* teaches “anti-parallel” ultrasonic paths. Thus, to the extent the combination would even be hypothetically possible, the combination of *Sheen et al.* and *Donelan et al.* do not teach the applicant’s claimed invention as a whole.

Also, contrary to the Examiner’s assertion, it is not at all obvious that anti-parallel path directions in tag flow measurement would lead to a meaningful result. It is the applicant that discovered – what many skilled in the art failed to recognize for at least twenty-five years prior to the applicant’s invention – that despite reversal of the path direction between the first and second signal paths, the signal modulation passively introduced along two paths by eddies or other scatterers in the flowing fluid remain relatively similar; that the signals received along the two paths are well-correlated. See, e.g., the application at page 6, lines 6-9.

Accordingly, independent claim 1, and claims 2-7 which depend from claim 1, are in condition for allowance. Also, because independent claims 8 (system, including a signal processor and a correlator) and 13 (method) include, inter alia, clamp-on transmitter receiver pairs, anti-parallel paths across the conduit and tag-modulated signals, independent claims 8 and

13, and the claims which depend from them, namely, 9-11 and 14, are also in condition for allowance.

*Bruner* Teaches Away From Applicant's Claimed Invention and Teaches Away From the Primary Reference *Sheen et al.*

The Examiner also rejects claims 2, 5-6, 11 and 14 as being unpatentable over *Sheen et al.* in view of *Donelan et al.* and further in view of U.S. Patent No. 4,528,857 to *Bruner*. For the reasons stated above, dependent claims 2, 5-6, 11 and 14 are in condition for allowance.

Additionally, *Bruner* teaches away from the applicant's tag flow measurement system because *Bruner* teaches a phase modulation ultrasonic flow meter. *Bruner* teaches that ultrasonic beams traversing the conduit are phase modulated. According to *Bruner*, "[t]he ultrasonic beams 32a and 32b are phase modulated by turbulence in the fluid flow in going from the transmitting transducers 24 and 28 to the receiving transducers 26 and 30 respectively". Column 3, lines 58-62. "[T]he phase modulated signals are picked up by the receiving transducers and then filtered, amplified, and synchronously phase demodulated". Column 2, lines 35-38. The phase modulation of the beam is attributable to those components of the instantaneous fluid velocity which are transverse to the mean flow direction. See *Bruner* column 3, lines 62-65.

In contrast, the applicant claims tag modulation, where the energy transmitted through the fluid and received by the receivers is passively modulated by scatterers present in the fluid flowing in the conduit so as to acquire a signature at each instant in time characteristic of the inhomogeneities through which the received signal has passed. The fluid itself passively provides tags that are assumed to move with the flow stream. It is known in the art that with tag



modulation the tags present in the flow path at a first position  $x_0$  at initial time  $t_0$  will be located at a second position  $x_1$  at a second time  $t_1$ , where the second position  $x_1$  is the product of the velocity  $V$  and time difference  $t_1 - t_0$ , where  $V$  is the velocity of the low density gas or steam in the conduit. The presence of substantially identical tags in the flow at two distinct places at a first and second time  $t_0$  and  $t_1$  is detected by correlation of the two received signals to determine a time interval indicative of the time taken for fluid to travel the distance  $L$  separating the two reception paths.

Also, *Bruner* teaches frequency meters or RMS volt meters to measure either the zero crossing frequency or amplitude of the resulting voltage signal, both quantities being nearly linearly related to the fluid flow rate. In contrast, as noted, the applicants claim a processor or a correlator to determine a time interval between tag-modulated signals, the time interval being indicative of flow. Compare the *Bruner* Abstract and column 3, lines 58-62 and column 2, lines 3-5, with the applicants' independent claims. See also the application at page 1, lines 10-13.

Also, *Bruner* teaches that the receiving transducers then transmit the received signals to respective bandpass filters with narrow bandwidths to eliminate crosstalk between the two loop circuits, column 2, line 65 through column 3, line 2, and a differential amplifier to cancel out portions of the demodulated signals due to sources other than transverse fluid components. Column 4, lines 61-63. *Bruner* teaches an alternative embodiment with a single path, see Fig. 2, in contrast to the applicant's claimed invention, and foretelling a fundamentally distinct system. In this alternative embodiment, *Bruner* teaches a high-pass filter connected to the receiving transducer to eliminate "undesirable low frequency noise due to flow turbulence or other sources". Column 6, lines 8-10.

In contrast, the applicant claims anti-parallel ultrasonic signal paths to reduce crosstalk

in the conduit, and that the tag-modulated output signals of the transmitter receiver pairs are correlated. In addition, *Bruner* teaches transmitting and receiving transducers which, after filtering, have their output signals combined in a differential amplifier to eliminate the interferences of temperature and pressure. Column 3, line 35. In contrast, the applicants' claimed invention correlates the tag-modulated signals and the timing ( $t_1 - t_0$ ) is not interfered with by temperature and pressure.

Moreover, the applicant has noted that *Sheen et al.* and *Bruner* teach away from one another, and neither separately nor combined teach all of the elements of the applicant's claimed invention. It does not necessarily follow that alleged teachings of *Bruner* regarding different frequencies, demodulated signals, or use with different conduit sizes would be combinable or work with a system such as *Sheen et al.* that relies on fundamentally different principles altogether. For example, *Bruner* teaches a "non-invasive" ultrasonic flowmeter. In contrast, *Sheen et al.* teaches an "acoustic decoupler" 12 between pipe sections. Also, *Bruner* teaches the use of phase modulation of the ultrasonic signals. In contrast, *Sheen et al.* teaches the use of cross-correlation of the noise signal. Also, although different frequencies were known at the time of *Sheen et al.*, *Sheen et al.* instead teaches cutting the conduit and inserting a decoupler. In short, *Sheen et al.* and *Bruner* are not properly combinable, and there is no teaching, incentive or motivation supporting their combination. In any event, they do not and would not combine to teach or suggest the applicant's claimed invention.

Also, contrary to the Examiner's assertion, using anti-parallel tag flow measurement on small pipes would not be obvious because it is known that the amount of (necessary) signal jitter generated by interaction with the fluid over a very short path becomes smaller as pipe diameter decreases until eventually the diameter is so small that flow is laminar and there is no jitter.

However, the applicant's claimed invention works despite the problems of more crosstalk noise and less signal in small conduits.

The Elements of Applicant's Claims Are Not Inherent In Bruner

With respect to the issue of possible "inherency" discussed above, the applicant's claimed invention is not inherent in *Bruner* for the reasons stated, including the fact that *Bruner* is limited to utilization of turbulence only, column 2, lines 3-5, and *Bruner* is limited to diametrically transverse paths, and that according to *Bruner* the ultrasonic beams are phase modulated by turbulence in the fluid flow in going from the transmitting to the receiving transducers. See, e.g., column 2, lines 3-5 and column 3, lines 46-56, and column 3, lines 58-62. The applicant's claimed invention which utilizes tag flow measurement not limited to turbulent flow or to specific path angles, is not inherent in *Bruner* for those reasons as well.

*Itoh et al.* Teaches Away From Applicant's Claimed Invention and Is Not Properly Combinable With *Sheen et al.* and *Donelan et al.*

The Examiner also rejects claims 7, 12 and 15 under 35 U.S.C. §103(a) as being unpatentable over *Sheen et al.* in view of *Donelan et al.* as applied to claims 5, 8 and 13, and further in view of U.S. Pat. No. 5,503,035 to *Itoh et al.* Claims 7, 12 and 15 are dependent claims and thus are in condition for allowance for the reasons contained herein with respect to the independent claims upon which they are based. The existence of clamp-on transducers does not provide the motivation to combine clamp-on transducers on the outside a conduit with any type of fluid flow measurement system, particular the systems of *Sheen et al.* (which teaches an acoustic decoupler) and *Donelan et al.* (which teaches transducers in the fluid).

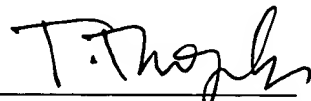
Moreover, in contrast to the applicant's claimed invention, which supplies noise reduction and increased signal to noise ratio using anti-parallel ultrasonic signal paths, *Itoh et al.* teaches away from the applicant's claimed invention by teaching the use of pipe structures with deep grooves in order to reduce the level of noise. See *Itoh et al.* col. 10, lines 15-23 and Figs. 20, 21A and 21B.

#### CONCLUSION

Each of the Examiner's rejections has been addressed or traversed. Accordingly, it is respectfully submitted that claims 1-11, 13 and 14 are in condition for allowance. Claims 12 and 15 have been cancelled. New dependent claims 16 and 17 depend from independent claim 1, and thus for the reasons stated herein are also in condition for allowance. Early and favorable action is respectfully requested.

If for any reason this Response is found to be incomplete, or if at any time it appears that a telephone conference with counsel would help advance prosecution, please telephone the undersigned or his associates, collect in Waltham, Massachusetts at (781) 890-5678.

Respectfully submitted,

  
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